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SPECIFICATION FOR DIAL, SCALES AND INDEXES FOR INDICATING ANALOGUE MEASURING INSTRUMENTS

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MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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October 1985

Indian Standard

SPECIFICATION FOR DIAL, SCALES AND INDEXES FOR INDICATING ANALOGUE MEASURING INSTRUMENTS

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Indian Standard

SPECIFICATION FOR DIAL, SCALES AND INDEXES FOR INDICATING ANALOGUE MEASURING INSTRUMENTS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 10 January 1985, after the draft finalized by the Industrial Process Measurement and Control Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard specifies the requirements for design and dimension of dials, scales and indexes for indicating analogue measuring instruments in which an index moves in relation to a fixed array of scale marks or the scale moves in relation to the fixed index to indicate the value of measured quantity to an observer. The basic designs are derived for scales for single, dual and multi-range instruments to cover the measuring for parameters, namely, pressure, flow, level, temperature, humidity, smoothness, viscosity, decibal, illumination, *p*H concentration, and also composition of constituents.

0.3 While preparing the standard, assistance was derived from BSI 81/31013 'Draft standard specification for scales and indexes for indicating analogue electrical measuring instruments [*revision* of BS : 3693 (Part 1)-1964]' and also data and drawings supplied by M/s Instrumentation Ltd, Kota.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard covers the requirements for dials, scales and indexes of indicating analogue instruments.

---

*Rules for rounding off numerical values (*revised*).

1.2 This standard does not cover dials and scales of glass thermometers and other instruments in which the indication is read directly by the level of liquid without any pointer.

1.3 This standard does not cover the requirements of ribbon type indicator or bargraph indicator.

1.4 This standard does not cover scales which are read by magnification with an optical device or by projection on a screen.

1.5 This standard does not specify the accuracy of calibration of indicating instrument to which the scales are applied.

2. TERMINOLOGY

2.0 for the purpose of this standard the following definitions (*see also* Fig. 1) shall apply.

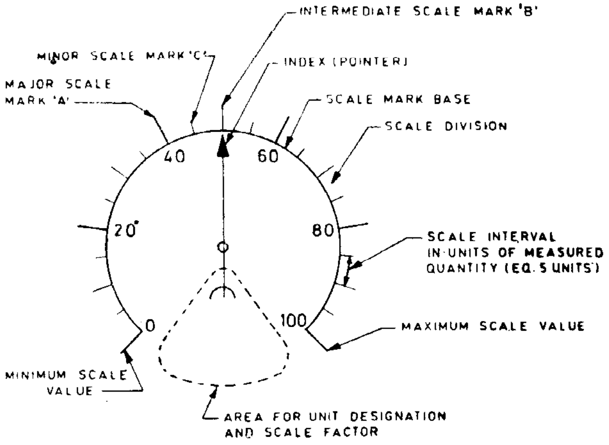


FIG. 1 NOMENCLATURE FOR DIALS AND SCALES

2.1 Dial — Portion of the instrument on which is inscribed the scale, scale number, inscriptions and symbols characterising the instrument.

2.1.1 *Index Path* — The line of travel, relative to the scale of that point on the index, or on the geometric prolongation of the index, which is effective in indicating the value of the quantity measured.

2.1.2 *Boundary Line* — A line, perpendicular to the scale marks, bounding the scale. The boundary line may be coincident with the scale mark base or it may be arranged on the opposite side of the scale.

2.2 Index (Pointer) — This is sometimes referred to as a pointer and is the means by which the position of the moving element of an instrument relative to the scale is indicated.

2.3 Scale — The series of marks and numbers from which, in conjuction with the index, the value of the measured quantity is obtained.

2.3.1 *Direct Scale* — A scale graduated directly in units measured by the instrument, together with its non-interchangeable accessory, if any, and the reading constant being 1. An instrument may have several direct scales.

2.3.2 *Converted Scale* — A scale graduated directly in units, when the quantity measured by the instrument together with its accessory, if any, is different or the reading constant differs from unity or both.

2.3.3 *Derived Scales* — A scale graduated in units other than that of the transmitted signal.

2.4 Graduation — The process of setting out a scale.

2.5 Scale Marks — Marks on the dial for the purpose of dividing it into suitable intervals so that the position of the index may be determined.

2.5.1 *Major Scale Marks* — The scale marks which form the primary dividers of the scale. Major marks are emphasized generally by elongation relative to the minor marks, or by thickening of all or part of the mark.

2.5.2 *Intermediate Scale Mark* — The scale marks which may be used, in some instances, to empahsis certain minor marks for the purpose of providing guidance in reading the scale between major scale marks.

2.5.3 *Minor Scale Marks* — The scale marks which form secondary division of the scale. Each interval between the major scale marks is divided into a number of scale divisions delineated by minor scale marks.

2.5.4 *Scale Mark Base* — The line, actual or implied, in the arc of a circle or straight, to which one end of all the scale marks and (or would be) tangent and corresponding to the maximum and minimum values of the scale.

2.6 Scale Division — The space between two consecutive scale marks is termed as scale division.

2.7 Interpolated Resolution — The smallest change in the measured quantity to which a numerical value can be assigned by interpolation, that is, by estimating the distance between the index and the nearest scale mark. It is expressed as a percentage of the scale range.

2.8 Resolution Factor — Number designated 'r' having the same numerical value as the interpolated resolution.

2.9 Scale Range — The number of units of the measured quantity indicated on the scale between two scale and marks.

2.10 Scale Factor — The number, if any, by which the indication is multiplied to obtain the value of the measured quantity.

2.11 Measuring Range (Effective Range) — The range defined by two values of the measured quantity within which the limits of error of a measuring instrument are specified.

2.12 Resolution — The smallest change in the measured or supplied quantity to which a numerical value can be assigned without interpolation.

2.13 Accuracy — The quality which characterises the closeness of the indicated value of an instrument to the true value and is normally expressed in terms of percentage of full scale value.

3. CLASSIFICATION

3.1 Dial

3.1.1 Dials shall be classified into the following categories:

Characteristics	*Classifications*
Shape	Flat Curved (*see* Fig. 2 and 3) Cylindrical (*see* Fig. 4) Conical (*see* Fig. 5)
Design	Stationery Moving

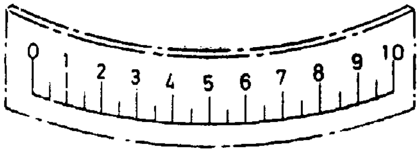


Fig. 2 Typical Curved Dial

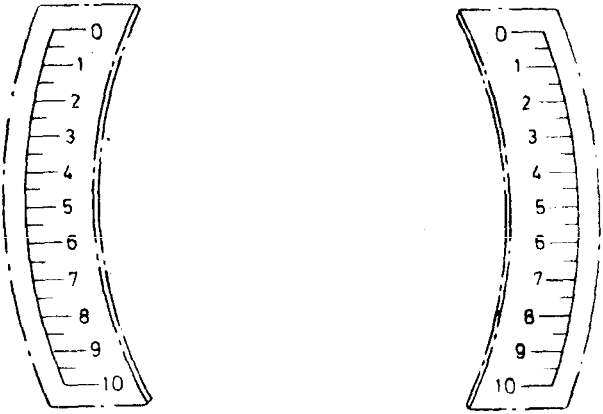


FIG. 3 TYPICAL CURVED DIAL (VERTICAL TYPE)

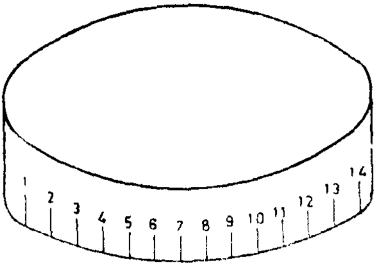


FIG. 4 TYPICAL CYLINDRICAL DIAL

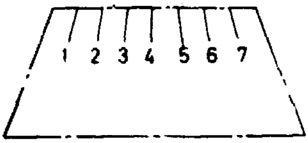


FIG. 5 TYPICAL CONICAL DIAL

3.2 Scales

3.2.1 Scales insribed on the dials shall be classified into the following categories:

Characteristies	*Classification*	
Method of drawing	Linear	Horizontial (*see* Fig. 6) Vertical (*see* Fig. 7)
	Segmental, for angle of curve upto and including 180°.	Horizontal (*see* Fig. **8**) Vertical (*see* Fig. 9) Oblique (*see* Fig. 10)
	Circular, for angle of curve more then 180° (*see* Fig. 11)	
Position of marking	Uniform Non-uniform	
Illumination	Nonluminous Illuminated by direct or diffused light luminous (with luminous matter of permanent or intermittant activity)	
Position of zero	Left hand or right hand zero Top or bottom zero Centre zero Without zero	
Number of rows in scales	Single row Double row Multi row	
Graduation	Direct Converted Derived	
Distance of reading	Distant reading Close range reading	

4. GENERAL REQUIREMENTS

4.1 The dials shall not deteriorate, corrode or deform under the influence of temperature and humidity of the environment and should withstand radiation, biological attack, shocks, vibration, and impacts and other similar influences.

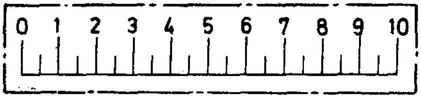


FIG. 6 TYPICAL HORIZONTAL SCALE (LINEAR)

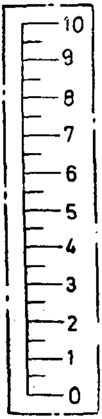


FIG. 7 TYPICAL VERTICAL SCALE (LINEAR)

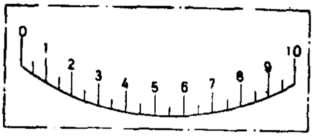


FIG. 8 TYPICAL HORIZONTAL SCALE

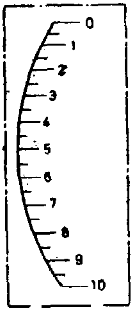


FIG. 9 TYPICAL VERTICAL SCALE

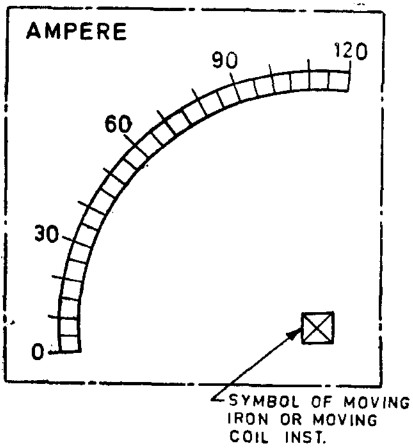


FIG. 10 TYPICAL OBLIQUE SCALE

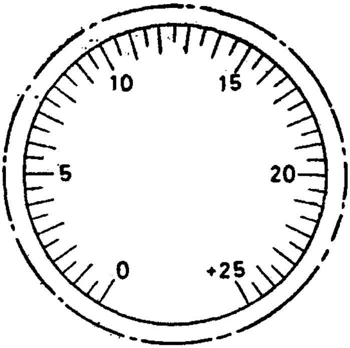


FIG. 11 TYPICAL CIRCULAR SCALE

4.2 The front surface of the dials with non-luminous scales shall preferably be white. Tinge of light shade is permissible. The surface of this scale should preferably have matty finish.

4.3 Colour of the dials with illuminated scales shall be as agreed to between the manufacturer and the purchaser.

4.4 Following details shall be marked on the dial:

a) Unit, and

b) Scale factor.

4.5 Scale, numerals, inscriptions, and symbols on the dials shall be sharp and well defined and should not deface, discolour or peel off.

4.6 Scale marks, special marks, numerals, inscriptions and symbols on white dials shall be black. Different portions of the scale, special marks, numerals inscriptions and inscriptions on a dial, if necessary, may be made in bright red, light green or light blue colour.

4.7 Scale marks in colours other than black or dark coloured on a white or light coloured background to produce sufficient contrast are also permitted. The surface of such scale should preferably have matty finish to avoid glare.

5. FACTORS INFLUENCING SCALE DESIGN

5.1 There are two major requirements to be met in the design of scales.

5.1.1 *Interpolation to the Required Interpolated Resolution* — It should be possible for a practised observer to interpolate a scale division to the required interpolated resolution. This resolution should bear some relationship to the intrinsic accuracy of the instrument of which the scale and index form part. The resolution factor should be equal to or less than the accuracy class of the instrument.

The statistical basis adopted for this standard is that in at least 95 observations out of every 100 taken by practised observers positioned directly in front of the scale, a reading shall not depart from the indicated value by more than the actual resolution of the scale when the illuminance (intensity of illumination) of the dial has a minimum value of 130 lux.

Note — Any special relationship should be specified by the appropriate instrument specification or the instrument manufacturer.

5.1.2 *Speed of Observation* — Where quickness of observation is a factor to be considered, interpolation to the required resolution is important. For general applications the speed of observation becomes more important as the required resolution index becomes coarser, and vice versa. It is important, for instance, that a motor car speedometer which would normally have a resolution factor of the order of 1, be read quickly without gross observational error, while quickness of observation is of much less importance when reading laboratory test instruments.

5.2 Interpolation — The following points are to be considered while designing the scale in order to keep the observation errors within the limits resulting from interpolation.

5.2.1 The proportion of observation errors increases rapidly when the angle subtended at the eye by the interpolated division becomes less than approximately 0·000 7 radians and again increases, though more slowly, as the subtended angle exceeds this figure.

NOTE — Alternatively, this is approximately 2½ minutes of arc.

5.2.2 Where quickness of observation plays no important part in the reading process there may be some additional advantage in the reduction of observational errors by choosing the minor division such that interpolating into halves achieves the required resolution factor. In practice this advantage has significance only with finely divided scales.

5.2.3 To remove the need for metal calculation and hence to minimise mistakes, interpolated division should be decimally related to 1, 2 or 5 units of the measuring quantity.

6. DIVISION AND MARKING OF THE SCALES

6.1 Scale alongwith the whole of its length shall be devided by major scale marks denoted by 'A' in Fig. 1.

The major scale intervals shall be divided by intermediate scale marks denoted by 'B' and these shall be further divided by this scale marks denoted by 'C'.

6.2 There should never be more than 5 minor divisions between intermediate divisions. Also there should not be more than 5 intermediate divisions in a major division.

6.3 There should not be more than 4 unfigured major marks between figured major marks and 2 unfigured marks between adjacent figured marks.

6.4 For uniform scales the number of divisions between scale marks 'A' and 'B' shall be similar for entire span of the scale.

6.5 Special marks and marks extending the scale beyond the figured marks may also be inscribed on the dial, if required by the conditions of use of the instruments.

6.6 The scale factor should be specified on the scale in the segment between the minimum and maximum scale marks for the circular scale.

6.7 Marking indicated in the various scales should be clearly visible at the minimum distance of 1 metre from the observer, with normal observation power.

7. SCALE LENGTH AND READING DISTANCES

7.1 Basis for Setting Out Scales — The basis for setting out all scales is the scale length. and this basis applies equally whether the scale is full circle, part-circle or straight. The dimensions of the scale are related to the intended distance at which the scale is to be read with the minimum number of observation errors.

7.2 Minimum Acceptable Scale Length — The minimum acceptable scale length can be determined as follows:

where

n = total number of interpolated divisions,

r = resolution factor,

D = distance from which the scale is read (mm), and

L = scale length (mm)

By definition $N = \frac{100}{r}$

From **5.2.1,** $L = 0{\cdot}0007, D.n.$

Therefore $L = \frac{0{\cdot}07\, D}{r}$

The above formula results in the minimum acceptable scale lengths. This may, with advantage, be increased by a factor of up to 3, especially when the application of the formula results in a scale length in appropriate to the instrument moving element or for instance, in the interests of uniformity.

7.2.1 The scale of instruments intended for 'close reading' should be designed for a reading distance of 300 mm. For panel mounted instruments a reading distance of 1 m may be more appropriate.

7.3 Examples of Scale Lengths for Reading Distances of 300 mm and 1 000 mm — Based on the above formula, examples of typical scale lengths for two reading distances of 300 mm and 1 000 mm are given for resolution indexes of 0·2, 0·5 and 1·0 in Table 1. The method of designing scales for all resolutions ranges and reading distances is given in Fig. 12.

TABLE 1 EXAMPLE OF SCALE LENGTHS FOR READING DISTANCES 300 mm AND 1 000 mm

(*Clause* 7.3)

NOMINAL READING DISTANCE (D) IN mm	*Min*, LENGTH (L) FOR RESOLUTION FACTOR (r) IN mm		
	0·2	0·5	1·0
300	105	42	21
1 000	350	140	70

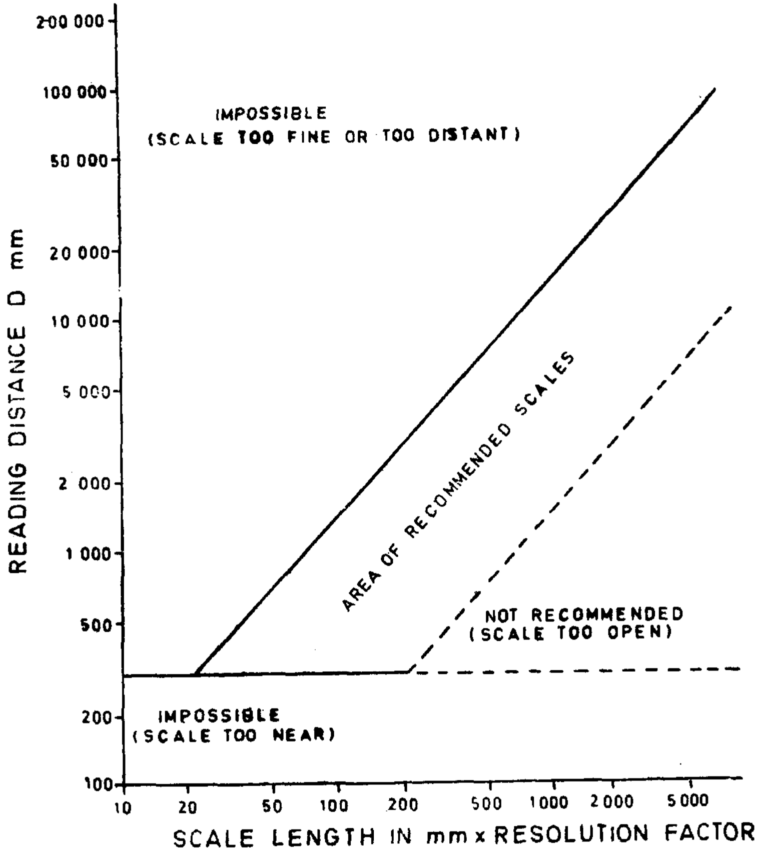


FIG. 12 RELATION BETWEEN READING DISTANCES AND SCALE LENGTH WITH RESPECT TO RESOLUTION FACTOR

8. LENGTH OF SCALE MARKS

8.1 The length of the scale marks on the scale shall conform to values given in Table 2. Scale marks A shall be longer than B and the scale marks B longer than C. The scale mark B shall not be less than 1·3 times or more than 1·5 times the length of the scale mark C and the length of the scale mark A shall not less than 1·7 times or more than 2 times the length of the scale mark C.

8.2 For dials containing more than two scales and for circular scales the scale marks A, B and C shall be of half the length specified in Table 2. But the length of the smallest scale mark shall not be less than 1 mm.

8.3 The deviation in the lengths of similar scale marks on the same scale shall be as follows:

0·2 mm for length of scale mark up to and including 4 mm; and

0·5 mm for length of scale mark above 4 mm.

8.4 Any special mark on the scale shall differ from the scale marks A, B and C in length or colour.

9. WIDTH OF SCALE DIVISION

9.1 The smallest width of the division of the scale shall not be less than the values given in Table 3. In exceptional cases smaller width shall also be used, however, it shall not be less than 0·5 times the distance on the scale corresponding to the absolute value of the allowable basic error of the instrument.

9.1.1 For uniform scales the maximum width of the division of the scale in instruments of accuracy class 1 and lower shall not be more than 3 times the distance on the scale corresponding to the allowable basic error of the instrument and for non-uniform scale this value shall not be more than 5 times.

9.2 The requirement for the maximum width of the division shall not be applicable for non-uniform scales of such instruments the principle of operation of which does not permit achieving this condition.

10. THICKNESS OF THE SCALE MARKS

10.1 Scale marks A, B and C for portable instruments of accuracy class 0·5 and better shall be of the same thickness and not exceeding 0·2 mm. For other instruments the thickness of the scale marks

TABLE 2 LENGTH OF SCALE MARKS (in mm)

(*Clause* 8.1)

SPECIFIED LENGTH OF THE SCALE (mm)		PORTABLE INSTRUMENTS						PANEL MOUNTING INSTRUMENTS											
								Close Range Reading						Distance Reading					
		A		B		C		A		B		C		A		B		C	
		From	To	From	To	From	To	From	To	From	To	From	To	From	To	From	To	From	To
Up to and including	30	3	5	2	3·5	1	2	3	5	2	3·5	1	2	2	—	—	—	—	—
Above 30 up to and including	60	3	6	2·5	4·5	1·5	3	3	6	2·5	4·5	1·5	3	—	—	—	—	—	—
Above 60 up to and including	100	5	8	4	6	2·5	4	4	10	3	8	2	5	—	—	—	—	—	—
,, 100 ,,	150	5	10	4	8	2·5	5	6	12	4	9	2·5	6	10	20	8	17	6	15
,, 150 ,,	300	6	12	4·5	10	3	8	7	20	4·5	15	3	10	12	25	10	22	8	18
,, 300 ,,	600	6	12	4·5	10	3	8	38	20	5	15	3	10	15	30	12	25	10	20

TABLE 3 MINIMUM WIDTH OF SCALE DIVISION

(*Clause* 9.1)

Specified Length of Scale mm	Minimum Width of Scale Division of Instruments of Accuracy Class			
	0·5 and Higher	1·0	1·5	2·5
		mm		
Up to and including 30	—	0·5	0·5	0·5
Above 30 ,, 60	—	0·5	0·5	0·5
,, 60 ,, 100	0·4	0·5	0·5	0·8
,, 100 ,, 150	0·4	0·5	0·8	1·2
,, 150 ,, 300	0·4	0·8	1·2	1·8
,, 300 ,, 600	0·4	1·5	2·0	2·0

shall correspond to the values indicated in Table 4. The thickness of the scale marks A and B shall not be less than the thickness of the scale marks C. For the panel mounting instruments of accuracy class 1 and lower the scale marks A shall be thicker than B and scale marks B thicker than C.

10.2 When necessary for the distance reading scales, the portion of the figured marks lying outside the lines limiting them shall be made thicker as shown in Fig. 13.

10.3 For circular scales of the electrical measuring instruments, when the pointer is in the same place as the scale, the figured marks shall be inscribed in the form of a triangle. The apex of triangle shall be directed towards the pointer and the included angle at the apex of the triangle shall be in the range of 15 to 20 degrees.

10.4 Permissible deviation in the thickness of similar scale marks on the same scale shall be as follows:

0·05 mm for thickness of scale marks up to and including 0·5 mm.

0·1 mm for thickness of scale marks above 0·5 up to and including 1 mm

0·2 mm for thickness of scale marks above 1 mm.

NOTE — This condition does not apply to luminous scales, scales with specified length more than 600 mm.

TABLE 4 THICKNESS OF THE SCALE MARKS (mm)

(*Clause* 10.1)

SPECIFIED LENGTH OF THE SCALE (mm)	PORTABLE INSTRUMENTS OF ACCURACY CLASS 1·0 AND LOWER						PANEL MOUNTING INSTRUMENTS											
							Close Range Reading						Distance Reading					
	A		B		C		A		B		C		A		B		C	
	From	To	From	To	From	To	From	To	From	To	From	To	From	To	From	To	From	To
Up to and including 30	0·1	0·3	0·1	0·3	0·1	0·3	0·2	0·5	0·2	0·3	0.1	0·3	—	—	—	—	—	—
Above 30 up to and including 60	0·1	0·3	0·1	0·3	0·1	0·3	0·3	0·6	0·2	0·4	0·1	0·3	—	—	—	—	—	—
,, 60 ,, 100	0·1	0·5	0·1	0·3	0·1	0·3	0·3	1·0	0·2	0·6	0·1	0·4	—	—	—	—	—	—
,, 100 ,, 150	0·1	0·7	0·1	0·4	0·1	0·4	0·5	1·5	0·2	0·8	0·1	0·5	1·5	3	1·0	2·5	0·5	2·0
,, 150 ,, 300	0·1	1·0	0·1	0·7	0·1	0·7	0·6	2·0	0·3	1·2	0·1	0·8	2·0	4	1·5	3·0	0·7	2·5
,, 300 ,, 600	0·1	1·5	0·1	1·0	0·1	0·7	0·6	2·5	0·4	2·0	0·1	1·2	2·5	5	2·0	4·0	1·5	3·0

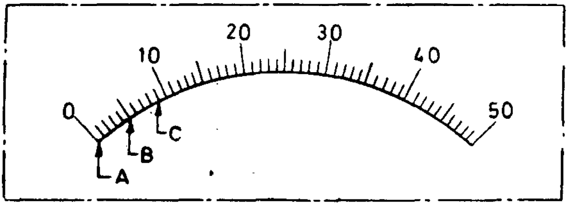


FIG. 13 THICKNESS OF SCALE MARK

11. SCALE NUMBERING

11.1 For the scale numberings the height indicated in Table 5 shall be followed. The scale numbering shall conform to the profile of "capital characters with normal contour".

TABLE 5 HEIGHT OE SCALE NUMBERS FOR DIALS (mm)

SPECIFIED LENGTH OF THE SCALE	PORTABLE	HEIGHT OF THE SCALE NUMBERS FOR DIALS OF INSTRUMENTS	
		Close Range Reading	Panel Mounting Distant Readings
(1)	(2)	(3)	(4)
Up to and including 30	2, 3, 5	2, 3, 5	—
Above 30 ,, 60	2, 3, 5	2, 3, 5	—
,, 60 ,, 100	3, 5	3, 4, 5	—
,, 100 ,, 150	3, 5, 8	3, 5, 8	12, 18, 24
,, 150 ,, 300	3, 5, 8	3, 5, 8, 12	12, 18, 24
,, 300 ,, 600	3, 5, 8	3, 5, 8, 12	12, 18, 24

12. LEAST COUNT OF THE SCALE

12.1 Least count of the scale shall be chosen from the series.

$$1 \times 10^{n};\ 2 \times 10^{n};\ 5 \times 10^{n};$$

where *n* is zero or any integer, positive or negative.

12.2 For the scales of multirange instruments the least count can also be chosen from the following series:

$1{\cdot}25 \times 10^{n}$; $1{\cdot}5 \times 10^{n}$; $2{\cdot}5 \times 10^{n}$; 3×10^{n}; 4×10^{n}; 6×10^{n}; 8×10^{n}; where *n* is zero or any integer, positive or negative.

12.3 This shall not be applicable to null indicators.

12.4 For uniform scales the least count alongwith the entire length of the scale shall be the same.

12.5 For instruments having constant least count for the entire effective range of the scale the divisions on the extreme ends can have least count differing from that for other divisions. In such a case the scale marks indicating such a division shall be smaller, in length than the preceeding scale mark but not less than 2/3rd of the smallest scale mark on the scale shown in Fig. 14.

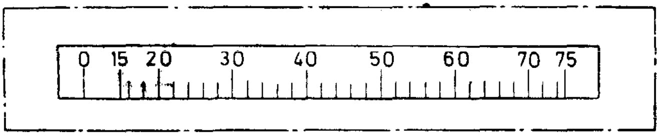
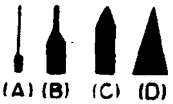


FIG. 14 LEAST COUNT FOR EFFECTIVE RANGE

13. INDEX (POINTER)

13.1 Since the essential requirement is the accuracy of location of the index tip, the index, sometimes referred to as a pointer, should have a pointed tip or the tip could be a narrow blade. Where the tip is pointed the penetration of the index tip over the scale should be between 1/3 and 2/3 of the length of the minor scale mark. Recommended shapes of index are shown in Fig. 15.



(A) is recommended for resolutions up to 0·5 and multiple scales

(B) is recommended for resolutions above 0·5 but below 1·0

(C) and (D) are recommended for resolutions 1·0 and above

FIG. 15 RECOMMENDED SHAPES OF INDEX (POINTER)

14. PARALLAX

14.1 From consideration of the geometry of the diagram shown in Fig. 16 it is clear that the error introduced by parallax can be reduced by making the fraction d/D small.

where d = distance of index from dial, and

D = distance of observer from dial.

The error due to parallax is likely to be larger for shorter reading distances, as there is the practical difficulty of reducing the distance of the index from the dial below a certain amount.

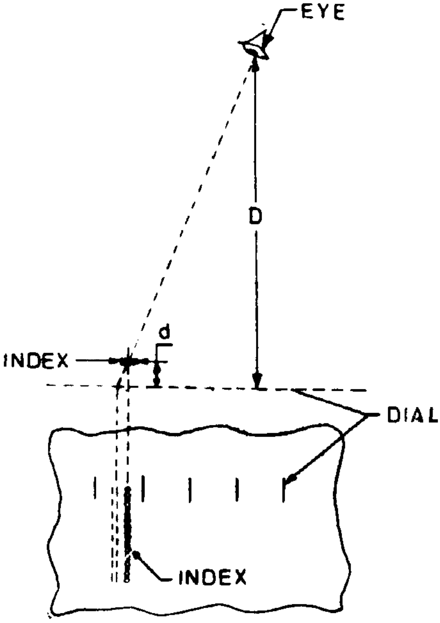


FIG. 16 EFFECT OF PARALLAX

14.2 In general, the recommendations given in this standard are based on the ability to read scales to one-fifth of a division. If the distance between the index and the scale is equal to one-fifth of a division and the value indicated is read at an angle of 45° to the normal, an observation error equal in magnitude to the resolution is introduced. Furthermore the scale division appears smaller to the observer; thus the probability of making on observation error is increased.

14.3 Where scales have to be viewed from a "fixed" position, care should be taken in so arranging the instruments that they are viewed normally, as far as practicable, that is from a point at right angles to the plane of the dial.

14.4 One type of construction is known as the "platform" dial in which the dial is stepped immediately adjacent to the ends of the scale marks, to take the index. Index and scale marks are thus in the same plane, and errors solely due to parallax will be reduced. Nevertheless, the divisions will appear smaller where viewed at an angle, and further, as the index tip must necessarily stop short from the ends of the scale marks, an observation error may be introduced due to the necessity of visually projecting the index tip on to the scale.

14.5 Where scales are to be read at short distances, an antiparallax mirror may be provided. This mirror should enable an observer to line-up the position of the eye in relation to the index so that it bisects the reflection of the pupil of his eye. Thus the scale is viewed at right angles in the region of the index, thereby reducing the total observation error. This form of construction also assists if scales are read at short distances, where parallax errors can result from binocular vision. The index must be thin and parallel-sided for a length which exceeds the width of the mirror. For scales having a small resolution factor one eye only should be used. It is also helpful if the underside (adjacent to the mirror) of the index is of a colour which contrasts with its sides and outer side as the correct viewing position is then indicated when the contrasting colour disappears.

15. OTHER DESIGN CONSIDERATION

15.1 The ends of the scale marks of a scale, if joined with one or two parallel straight lines (for linear scale as shown in Fig. 17 or curved lines) for segmental or circular scales as shown in Fig. 10, the thickness of these lines shall not be less than 0·1 mm and not more than the thickness of the scale marks.

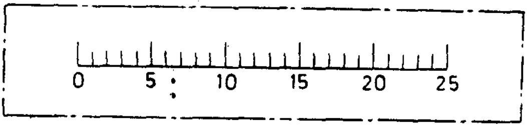


Fig. 17 Linear Scale

15.2 Marking of diagonal scales shall be permissible as shown in Fig. 16 and 18. Width of the division shall be made as specified in **9**. The thickness of the lines of diagonal scale shall not be less than 0·1 mm and not more than the thickness of scale mark G.

15.3 Effective range of the scale shall be distinctly separated from its non-effective range. To attain this the non-effective range of the scale shall be designated by triangles placed near the scale marks dividing the effective and non-effective range of the scale as shown in Fig. 19 or shall not have the curved or straight line joining the ends of the scale marks as shown in Fig. 20.

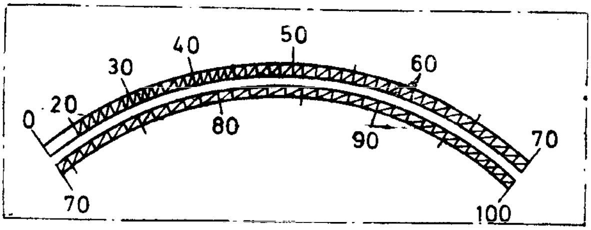


Fig. 18 Diagonal Scale Mark

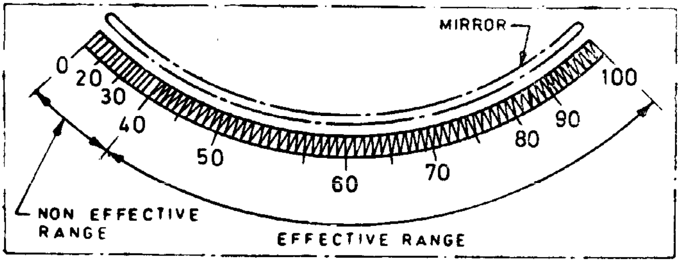


Fig. 19 Effective and Non-Effective Range

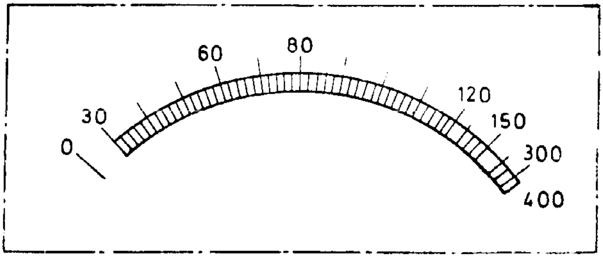


Fig. 20 Auxiliary Scale Marks

15.4 Besides the scales used for reading the measured quantity a dial can also have auxiliary scales used for calibrating and checking the instrument. The scale marks of the auxiliary scale shall be different in length, thickness or colour from those the scale of the instrument.

NOTE — The requirements for auxiliary scales are not covered in this standard. These requirements shall be as agreed to between the manufacturer and the purchaser.

15.5 Horizontal and vertical scales shall be symmetrical to one of the axis of symmetry of the dial. Oblique scales should be symmetrical to the diagonals.

15.6 The beginning of the scales shall be as follows:

For the horizontal scales it shall be the left hand portion of the dial and for vertical scales in the lower portion.

15.7 For other scales (oblique, segmental) it shall lie in the lower left hand portion of the dial.

15.8 When a dial has more than two scales, one of them can have the beginning scale mark on the right. The scale marks of all the other scales shall be so placed that the pointer can be brought to the beginning scale marks of all the scales at the same time as shown in Fig. 21.

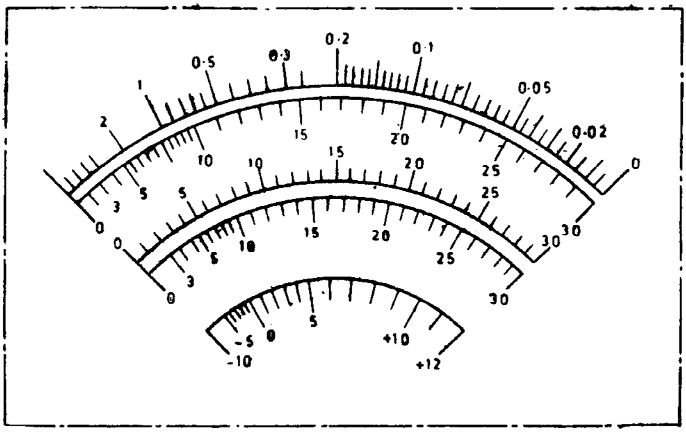


FIG. 21 DIAL WITH MORE THAN TWO SCALES

15.9 For instruments having such a principle of operation which does not permit the fulfilment of the requirements of this standard, some other position of beginning scale mark of the scale shall be permitted.

15.10 The axis of the scale marks shall coincide with the geometrical axis of the pointer over whole of the length of the scale.

15.11 For dials having mirror the distance of the scale marks at the extreme ends of the scales from the ends of the mirror shall be at least half the thickness of the last scale mark as shown in Fig. 22.

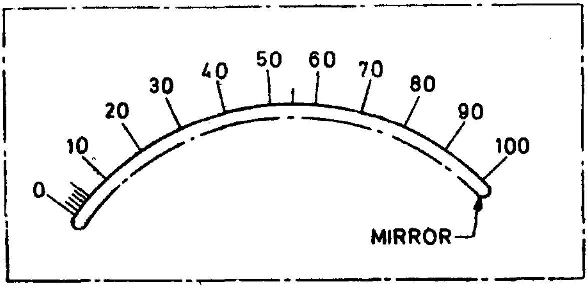


FIG. 22 DIAL WITH MIRROR

15.12 For dials with only one scale the distance between the mirror and the end of the scale marks nearest to the mirror shall not be more than half the width of the mirror.

15.13 Dial and Scale for Water Meter — There shall be five dial scales within one big dial as shown in Fig. 23. The individual dial scales read the flow of the liquid (water) in the range of 0-100, 0-10000, 0-100000 and 0-1 000 000 litre range.

15.14 Dual Scale for Pressure Gauge — The outer scale shall read say pressure up to a range of 0-72 mm Wcl and the inner scale from 72-140 mm Wcl as shown in Fig. 24. The window provided in the dial shall indicate the scale (outer and inner) which should be seen for reading the values.

16. SCALE NUMBERING, INSCRIPTIONS AND SYMBOLS

16.1 On any scale the scale numbers shall not be less than four. The figures shall normally be placed against the largest or thickest scale mark, if required they shall be placed at medium scale marks but not at both. A few longest or thickest scale marks can be left without figures so that the interval between two neighbouring figures is wider than the width of the biggest figure. If is essential to make this distance smaller, it shall not be less than one and a half times the width of one digit. For non-uniform scales, this distance shall be reduced and the figures written along the axis of symmetry of the scale marks as shown in Fig. 20.

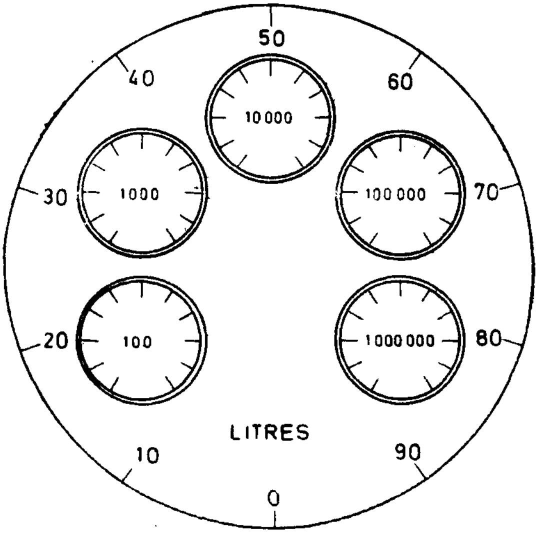


FIG. 23 TYPICAL REPRESENTATION OF DIALS AND SCALE FOR WATER METER

16.2 For various ranges of multi-range scales, the figures at the scale marks shall be multiples of *n* (where *n* is any integer/fraction/ decimal, positive or negative). More than one row of figures for markings can be inscribed and if the space on the dial is not sufficient, figures may be written only on the last scale marks as shown in Fig. 25.

16.3 Against the scale marks, where the least count of the scale changes the figures shall be placed without taking into consideration the size of the scale mark except for the conditions stipulated in **12.4**.

16.4 The figures at the extreme scale marks of the scale can be smaller in size than the others and for scales for specified length up to 100 mm they can be absent.

16.5 The figures shall be placed symmetrical to the corresponding scale mark, if the axis of the scale marks is parallel of perpendicular to the axis of the digits, the maximum draft of the figures in relation to axis of symmetry of the scale mark shall not be more than one-fourth the width of the digit for horizontal scales and one-fourth the height for vertical scales.

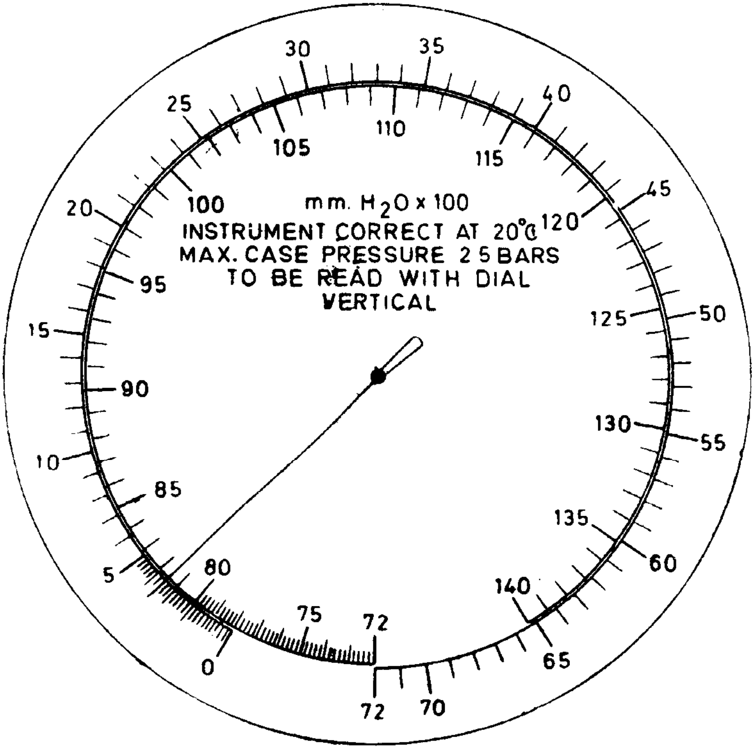


FIG. 24 TYPICAL REPRESENTATION OF MULTI-RANGE CIRCULAR SCALE INSTRUMENT (PRESSURE GAUGE)

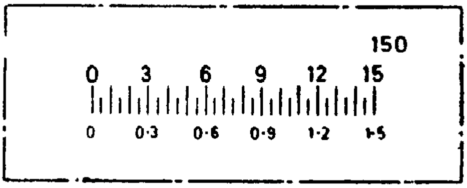


FIG. 25 MULTI-RANGE LINEAR SCALE

16.6 For instruments with individual calibration this draft of the figures in relation to the axis of symmetry of the scale marks should not be more than half the width or height of one digit.

16.7 The figure at the scale marks shall not be constituted of more than 2 digits, however, if essential a maximum of four digits shall be allowed. Figure with higher number of digits shall be shortened in the following manner:

a) Using a multiplying or fractioning designation of the units of measurement, and

b) Using a co-efficient 10^n (where n is any integer positive or negative) placed before the designation of the measured quantity and in the event of insufficient space at any clearly visible portion of the dial.

16.8 Before the co-efficient the sign of multiplication should also be placed as shown in Fig. 26.

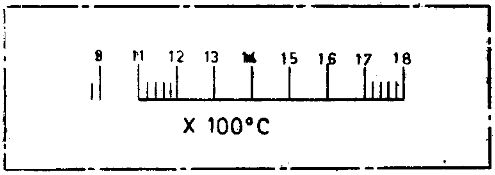


FIG. 26 TYPICAL EXAMPLE FOR MARKING SIGN OF MULTIPLICATION

16.9 Inscribed symbols and inscriptions shall be given in the dial characterizing the instrument and conditions of its usage, as specified in the specifications for the instrument.

16.9.1 Units of measurement or the nomenclature of the instrument shall be indicated on the dial in a central bottom portion between the extreme scale marks of the scale. For oblique scales the units of measurement or nomenclature of the instrument shall be indicated in the left hand top corner of the instrument.

16.9.2 The portion of the dial adjacent to the scale, having a minimum width equal to the length of the smallest scale mark and covered by the pointer, shall be free from the inscriptions contained on the dial except the figures and symbols for the units of measurement.